

**CLAIMS**

**What Is Claimed Is:**

- 5           1.     In an implantable cardiac stimulation device having a pulse generator for generating pacing pulses for applying to a heart of a patient and having a control circuit for controlling the pulse generator to apply overdrive pacing pulses to the heart using a set of control parameters, a method, performed by the control circuit, for automatically adjusting the
- 10   control parameters comprising:
- acquiring an initial set of control parameters;
- controlling the pulse generator, based on the set of control parameters, to overdrive pace the heart;
- determining a degree of overdrive pacing achieved using
- 15   the selected set of control parameters; and
- adjusting the set of control parameters so as to improve the degree of overdrive pacing to be achieved during further overdrive pacing.
- 20           2.     The method of claim 1 further comprising acquiring a desired overdrive pacing range.
3.     The method of claim 2 wherein adjusting the control parameters to vary the degree of overdrive pacing comprises:
- 25           selecting a control parameter to be adjusted
- comparing the degree of overdrive pacing achieved using the selected set of control parameters with the desired overdrive pacing range;
- if the detected degree of overdrive pacing exceeds the
- 30   desired overdrive pacing range, adjusting the selected control

parameter so as to decrease the degree of overdrive pacing; and  
if the detected degree of overdrive pacing is below the  
desired overdrive pacing range, adjusting the selected control  
parameter so as to increase the degree of overdrive pacing.

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4. The method of claim 3 further comprising inputting an order  
of priority of control parameter adjustment and wherein adjusting the set  
of control parameters is performed sequentially to hierarchically adjust the  
control parameters in the input order of priority.

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5. The method of claim 3 wherein the initial set of control  
parameters comprises one or more of: a number of overdrive events; an  
overdrive pacing response function; a recovery rate; a base rate; a rest  
rate; and a circadian base rate.

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6. The method of claim 5 wherein the number of overdrive  
events specifies a number of consecutive overdrive beats to be paced  
following initiation of overdrive pacing.

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7. The method of claim 6 wherein, if the number of overdrive  
events is to be adjusted, the number of overdrive events is decreased if  
the detected degree of overdrive pacing exceeds the desired overdrive  
pacing range and increased if the detected degree of overdrive pacing is  
below the desired overdrive pacing range.

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8. The method of claim 5 wherein the overdrive pacing  
response function specifies an overdrive pacing rate to be used for  
overdrive pacing the heart following initiation of overdrive pacing, with the  
overdrive pacing rate being dependent upon detected heart rate.

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9. The method of claim 8 wherein the overdrive pacing response function is selected from among a set of overdrive pacing response functions with overdrive pacing rates generally differing from one response function to another.

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10. The method of claim 9 wherein, if the overdrive pacing response function is to be adjusted, an overdrive pacing response function having generally lower overdrive rates is selected if the detected degree of overdrive pacing exceeds the desired overdrive pacing range and an overdrive pacing response function having generally higher overdrive rates is selected if the detected degree of overdrive pacing is below the desired overdrive pacing range.

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11. The method of claim 5 wherein the recovery rate specifies a rate decrement by which the overdrive pacing rate is decreased after the number of overdrive events have been paced.

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12. The method of claim 11 wherein, if the recovery rate is to be adjusted, the recovery rate is increased if the detected degree of overdrive pacing exceeds the desired overdrive pacing range and decreased if the detected degree of overdrive pacing is below the desired overdrive pacing range.

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13. The method of claim 5 wherein the base rate specifies a minimum non-overdrive pacing rate for use while the patient is awake.

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14. The method of claim 13 wherein, if the base rate is to be adjusted, the base rate is decreased if the detected degree of overdrive pacing exceeds the desired overdrive pacing range and increased if the detected degree of overdrive pacing is below the desired overdrive pacing

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range.

15. The method of claim 5 wherein rest rate specifies a  
minimum non-overdrive base rate for use while the patient is at profound  
5 rest.

16. The method of claim 15 wherein, if the rest rate is to be  
adjusted, the rest rate is decreased if the detected degree of overdrive  
pacing exceeds the desired overdrive pacing range and increased if the  
10 detected degree of overdrive pacing is below the desired overdrive pacing  
range.

17. The method of claim 5 wherein circadian base rate specifies  
a minimum non-overdrive base rate set based on an average active heart  
15 rate while the patient is awake and based on an average rest heart rate  
while the patient is at rest.

18. The method of claim 17 wherein, if the circadian rate is to  
be adjusted, the circadian rate is decreased if the detected degree of  
20 overdrive pacing exceeds the desired overdrive pacing range and  
increased if the detected degree of overdrive pacing is below the desired  
overdrive pacing range.

19. The method of claim 1 wherein determining the degree of  
25 overdrive pacing achieved using the selected control parameters  
comprises:

tracking the heart rate; and  
for each of a set of predetermined set of heart rate ranges,  
determining an overdrive pacing percentage indicative of paced  
30 heart beats to total heart beats.

20. The method of claim 19 wherein tracking the heart rate is performed over a period of 24 to 48 hours.

5 21. An implantable cardiac stimulation device comprising:  
a pulse generator that is operative to generate pacing  
pulses to be applied to a heart of a patient; and  
a control circuit that is operative to control the pulse  
generator to apply overdrive pacing pulses to the heart using a set  
10 of control parameters and for dynamically and automatically  
adjusting the control parameters so that a degree of overdrive  
pacing exceeds a predefined threshold.

15 22. The device of claim 21 wherein the control circuit comprises  
an overdrive pacing unit operative to  
input an initial set of control parameters;  
control the pulse generator, based on the set of control  
parameters, to overdrive pace the heart;  
20 determine the degree of overdrive pacing achieved using  
the selected set of control parameters; and  
adjust the set of control parameters so as to improve the  
degree of overdrive pacing to be achieved during further overdrive  
pacing.

25 23. The device of claim 22 wherein the overdrive pacing unit  
also inputs a desired overdrive pacing range.

24. The device of claim 23 wherein the overdrive pacing unit  
adjusts the control parameters to vary the degree of overdrive pacing by  
30 selecting a control parameter to be adjusted, comparing the degree of

overdrive pacing achieved using the selected set of control parameters with the desired overdrive pacing range, adjusting the selected control parameter so as to decrease the degree of overdrive pacing if the detected degree of overdrive pacing exceeds the desired overdrive  
5 pacing range, and adjusting the selected control parameter so as to increase the degree of overdrive pacing if the detected degree of overdrive pacing is below the desired overdrive pacing range.

25. The device of claim 24 wherein the overdrive pacing unit  
10 also inputs an order of priority for control parameter adjustment and adjusts the set of control parameters sequentially in the input order of priority to hierarchically adjust the control parameters.

26. The device of claim 24 wherein the initial set of control  
15 parameters input by the control circuit comprises one or more of: a number of overdrive events; an overdrive pacing response function; a recovery rate; a base rate; a rest rate; and a circadian base rate.

27. An implantable cardiac stimulation device comprising:  
20 means for generating pacing pulses for applying to the heart of a patient;  
means for acquiring an initial set of control parameters for use in overdrive pacing the heart;  
means for controlling the means for generating pulses,  
25 based on the initial set of control parameters, to overdrive pace the heart;  
means for determining the degree of overdrive pacing achieved using the initial set of control parameters; and  
means for adjusting the initial set of control parameters so  
30 as to improve the degree of overdrive pacing to be achieved during

further overdrive pacing.

28. The device of claim 27 wherein the means for adjusting the control parameters to vary the degree of overdrive pacing comprises:

5 means for selecting a control parameter to be adjusted  
means for comparing the degree of overdrive pacing achieved using the selected set of control parameters with the desired overdrive pacing range;

10 means, responsive to a determination that the detected degree of overdrive pacing exceeds the desired overdrive pacing range, for adjusting the selected control parameter so as to decrease the degree of overdrive pacing; and

15 means, responsive to a determination that the detected degree of overdrive pacing is below the desired overdrive pacing range, for adjusting the selected control parameter so as to increase the degree of overdrive pacing.

29. In an implantable cardiac stimulation device, a method comprising:

20 pacing a heart at an overdrive pacing rate specified by a set of control parameters;

determining whether a degree of overdrive pacing achieved using the set of control parameters falls below a threshold;

25 adjusting one or more of the control parameters if the degree of overdrive pacing falls below the threshold; and

using the adjusted set of control parameters for further overdrive pacing.